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IoT Based Baby Monitoring System for a Smart Cradle

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ABSTRACT

This project presents an Internet of Things (IoT)-based baby monitoring system for a smart cradle, designed to provide real-time monitoring and automation for infant care. The system is built using a NodeMCU microcontroller, integrating multiple sensors and actuators to ensure the baby's comfort and safety. Key components include a DHT11 sensor for monitoring the cradle's temperature and humidity, a sound sensor for detecting baby cries, a servo motor for automated cradle rocking, and a DC fan for environmental control. The DHT11 sensor continuously monitors the ambient conditions inside the cradle, ensuring that the temperature and humidity remain within comfortable levels. If the baby starts crying, the sound sensor detects the noise and triggers the servo motor to gently rock the cradle, soothing the baby. Additionally, a DC fan is automatically activated when temperature levels rise above a preset threshold to keep the environment cool. The NodeMCU connects to the cloud, enabling parents to monitor the baby's status remotely through a mobile application, which provides real-time alerts and controls using IoT platforms such as Blynk. This system not only enhances infant comfort and safety but also reduces the need for constant parental supervision by automating common tasks. The integration of IoT technology provides parents with remote access to monitor environmental conditions and intervene when necessary, making the smart cradle an innovative and efficient solution for modern baby care.

Keywords: IoT, Node MCU, DHT11, Actuators, Blynk.

INTRODUCTION

At present, female participation in the workforce in industrialized nations has greatly increased, thereby affecting infant care in many families. Both parents are required to work due to the high cost of living. However, they still need to look after their babies, thereby increasing workload and stress, especially for the mother. Working parents cannot always care for their babies. They either send their babies to their parents or hire a baby caregiver while they are working. Some parents worry about the safety of their babies in the care of others. Thus, they go home to check on their babies during their free time, such as lunch or tea break. A baby monitoring system that can monitor the babies' condition in real time is proposed to solve these problems. A baby monitoring system consisting of a video camera and microphone without limitations on coverage. It can send data and immediately notify the parents about urgent situations, thereby shortening the time needed to handle such scenarios. Generally, babies cry because they are hungry, tired, unwell, or need their diaper changed. Sudden Infant Death Syndrome (SIDS) is also known as crib death, because many babies who die of SIDS are found in their cribs. It occurs in infants younger than 12 months old.

Most SIDS deaths occur in infants younger than 6 months old. Professionals still do not know the causes of SIDS, but risk can be reduced by letting the baby sleep on a firm surface (crib mattress). In addition, the baby should not sleep on a pillow or another soft surface. The researchers do not know why sleeping on such surfaces increases the risk of SIDS, but they warn that it could be dangerous. For instance, in 2003, a study showed that placing an infant to sleep on soft bedding rather than on firm bedding appeared to pose five times the risk of SIDS. Moreover, overheating should be avoided during sleep. Babies should be kept warm during sleep, but the temperature should not be extremely warm. In winter or cold weather, the risk of SIDS increases because the parents overdress their babies or place them under a heavier blanket, thereby overheating them. Therefore, if the room temperature is comfortable for an adult, then it is also appropriate for the baby.

Problem Statement

Parenting in the modern era presents unique challenges, particularly for working parents who strive to balance professional responsibilities with the need for constant care and attention for their newborns. Traditional baby monitoring methods, such as audio monitors or manual observation, are often inadequate to provide real-time insights into the baby's well-being or ensure immediate intervention in critical situations. Additionally, caregivers face difficulties in maintaining an optimal

environment for the baby, such as ensuring appropriate room temperature, humidity, and soothing mechanisms, all of which are vital for the child's comfort and development. The absence of an integrated, automated, and reliable system to monitor and respond to a baby's needs can lead to increased stress and potential safety risks for the child. Parents often lack real-time awareness of crucial parameters, such as the baby's movements, crying patterns, or environmental conditions, especially when they are away from home. This creates a pressing need for an intelligent solution that not only monitors these factors but also automates responses to enhance the baby's comfort and safety.

The IoT-based Baby Monitoring System for Smart Cradle aims to address these challenges by providing a comprehensive solution that combines real-time monitoring, automation, and remote access. By leveraging IoT technologies, thesystem ensures continuous tracking of the baby's well-being and environmental conditions, automates essential tasks such as rocking and soothing, and offers parents the ability to monitor and control the cradle remotely. This innovation seeks to reduce parental stress, improve childcare efficiency, and ensure a safe and nurturing environment for the baby

LITERATURE SURVEY

The evolution of IoT-based smart cradle systems has significantly enhanced infant caregiving by integrating advanced technologies such as sensors, mobile applications, and artificial intelligence. Several studies, including those by Gulam Sarwar et al. (2022), Madhuri Joshi and Deepak Mehetre (2017), and S. Kavitha et al. (2019), highlight features like cry detection, temperature monitoring, automated swinging, and live video feeds, all designed to reduce parental stress and support remote supervision. These systems are not only responsive and user-friendly but are also scalable for environments like daycare centers.

Affordability and accessibility remain key themes across the literature. Jabbar et al. (2019), N. Saude and P.A.H. (2018), and Harshitha K. et al. (2020) focus on low-cost, modular systems suitable for diverse economic backgrounds and regions, including rural areas. Their systems combine essential monitoring features with ease of use, ensuring comprehensive caregiving without requiring advanced technical skills. Similarly, the systems proposed by W.A. Jabbar et al. (2019) and R. Ramli et al. (2021) emphasize practical, reliable solutions tailored for modern, busy families. Recent advancements also explore the integration of AI, RFID, GPS, and blockchain technologies for smarter, more secure baby monitoring. Studies by Victor Adewopo et al. (2022) and Nelly Elsayed et al. (2022) show how AI can predict risks and adapt to a baby's needs in real time. Meanwhile, researchers like Ruven Sundarajoo et al. (2022) and A.W. Jabbar et al. (2019) demonstrate the potential of technologies like GPS for mobile caregiving and blockchain for secure data sharing in healthcare settings. Collectively, these innovations pave the way for intelligent, responsive, and secure infant care systems.

METHODOLOGY

This methodology demonstrates how IoT technology, combined with innovative engineering and thoughtful design, can transform traditional baby cradles into intelligent systems. The IoT-based smart cradle offers a practical and scalable solution to modern parenting challenges, bridging the gap between technology and infant care. Through this system, caregivers can ensure their child's well-being while managing their daily responsibilities more effectively.
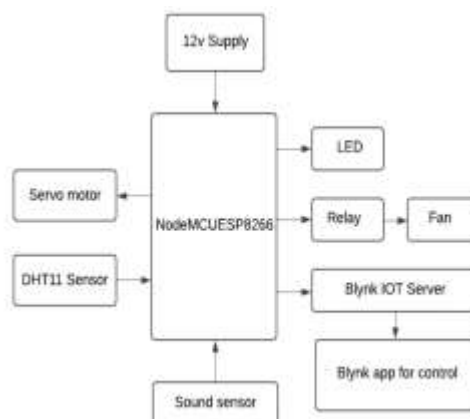
Fig. 1 Block Diagram

The above block diagram determines that if the baby is making noise or crying, then the sound sensor will hear that frequency, and it will startswinging. Also, a notification alert will be sent to the parent through the BLYNK APP. If the baby wets the mattress of the cradle, then an alert SMS will be sent to the parent through the BLYNK APP. If the body temperature of the baby changes rapidly compared tothe atmosphere, then an alert SMS will be sent to the parents through the BLYNK APP. If a baby is moving in a cradle or any kind of movement is detected by the PIR sensor, then the alert notification will be sent to the parent through the BLYNK APP. If the baby is crying and simultaneously wetness is detected, then the alert will be sent as the baby is crying due to wetness. Even after the cradle swing for five minutes,if the baby is still crying, then there will be high alert will be sent to the parent.

The proposed system is more reliable. The status of the baby is known by the father even if he is at the office, as a notification message is fired to the father at every movement of the baby, like crying, wetting of the mattress, etc. When the baby cries, the motor rotates, which in turn moves the cradle. If the baby continues to cry, the recorded sound of the mother is played. And the father is sent a notification message. When the baby tries to come out of the cradle, the inclination of the cradle above the specified limit blows the buzzer in the kitchen, and a text message is sent to the father, who is sitting in the office. Moreover, the mattress, if made wet by the baby, also sends a text message and blows an indicator.

The Internet of Things-based Baby Monitoring System (IoT-BBMS) is proposed as an efficient and low-cost IoT-based system for monitoring in real time. We also proposed a new algorithm for our system that plays a key role in providing better baby care while parents are away. In the designed system, the ESP32 Controller Board is exploited to gather the data read by the sensors and upload via Wi- Fi to the BLYNK APP Server. The proposed system exploits sensors to monitor a baby's vital parameters, such as ambient temperature, moisture, and crying. A prototype of the proposed baby cradle has been designed using AURDINO IDE software, and red meranti wood is used as the material for the cradle. The system architecture consists of a baby cradle that will automatically swing using a motor when the baby cries. Parents can also monitor their babies' condition through an external web camera and switch on the lullaby toy located on the baby cradle remotely.

Hardware And Software Description

The IoT-based smart baby cradle system employs a collection of electronic components to provide real-time monitoring and automated outputs for infant care. The power supply of the system is from a 12V DC output converter to the ESP32 microcontroller. The ESP32 is programmed and uploaded using Arduino IDE and utilizes Wi-Fi to transfer sensor data and receive commands.Each sensor used operates in its entirety, both independently and without hampering the data it'll provide as a system.

In this situation, the allowable code structure sequence is layered undercradle-designed logic flows. The system first connects to the Wi-Fi for remote data transmissionpurposes. When the baby is detected crying, the rotary actuator mechanism will automatically swing the cradle.For cry detection, the ARP33A3 audio voice module was demonstrated. It employs high-performance audio analog-to-digital converters (ADCs) and digital-to-analog converters (DACs), is capable of key-triggered playback and recording, and is a relatively low-cost solution.

In addition to the basic hardware, we will also remotely monitor the baby through an atmospheric camera for limited visibility, by incorporating a second night-vision camera.The temperature and humidity monitoring attributes will utilize a temperature & humidity sensor (DHT11/DHT22). When the DHT11/DHT22 state measured exceeds or falls below a threshold or limits, the relay modules will switch on devices that ward off or prevent a baby from getting wetthrough changing their diaper or removing upper clothes.

The Arduino Integrated Development Environment (IDE) is an open-source software platform used to write, compile, and upload code to Arduino and compatible microcontroller boards, such as the NodeMCU ESP8266. It provides a user-friendly interface that supports C and C++ programming with simplified syntax and built-in functions specifically tailored for hardware interaction.

The IDE consists of a code editor, message area, text console, and a toolbar with buttons for common tasks like verify, upload, and open or save files. One of its key features is the serial monitor, which allows real-time communication with the microcontroller to debug or display sensor data.

Fig. 2 Arduino IDE

In a smart cradle system, the Arduino IDE enables developers to write code that controls sensors and actuators. For instance, libraries like ESP8266WiFi.h and BlynkSimpleEsp8266.h are added using the IDE to enable Wi-Fi connectivity and Blynk app integration. The DHT.h library is included for reading temperature and humidity data, while the Servo.h manages servo motor movements. The IDE allows users to define logic, such as responding to a baby's cry by activating a servo motor or turning on a fan when the temperature exceeds a threshold. Once the code is written, it is compiled within the IDE and uploaded to the microcontroller through a USB connection. The simplicity and versatility of the Arduino IDE make it an essential tool for developing and deploying IoT-based embedded systems like smart cradles.
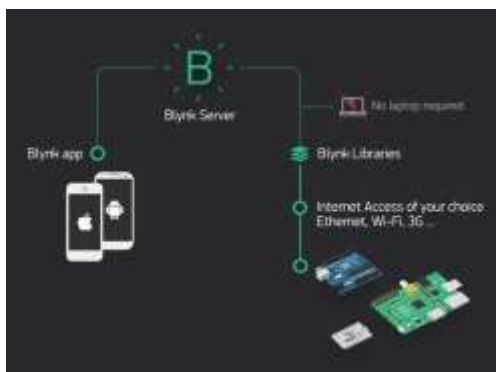
Fig. 3 Blynk Sever and App

RESULTS AND ANALYSIS

IoT-BBMS are presented in detail. shows the final prototype of the developed smart cradle. Several manufacturing steps were carried out prior to the implementation of the control system for the smart cradle.
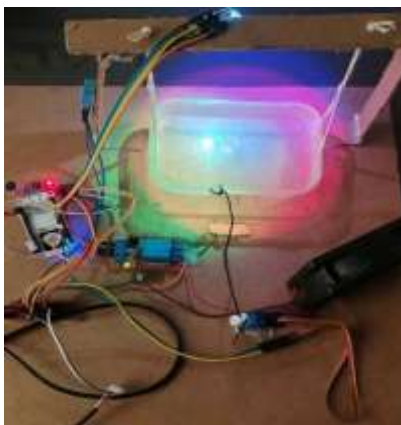
Fig. 4 Module Setup for IOT-BBMS
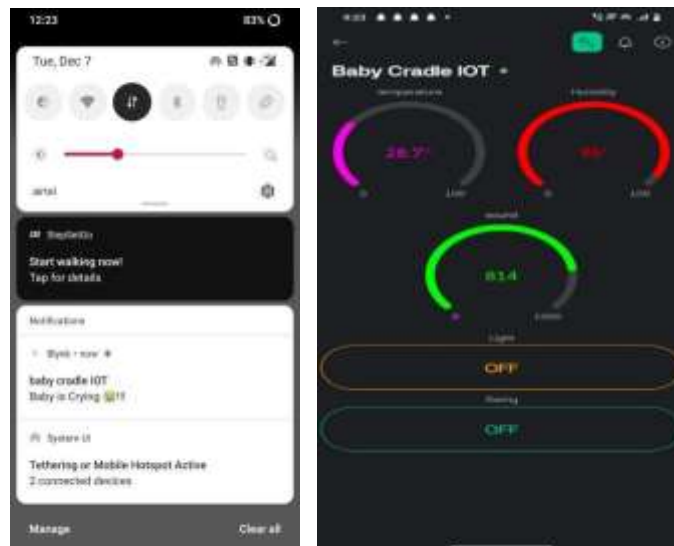
Fig. 5 Parent Notification And Sensor Data

In this setup, we have the temperature,humidity, and sound sensors.when we are giving the input, we will get the range of those sensors. we are giving breath to the humidity sensor, we can see the increase of humidity in the Blynk app, and we get a notification through the Blynk app.From the figure below, we can see the increase in humidity in the humidity sensor.

Advantages And Applications

Baby cradles offer numerous advantages, combining comfort, security, and convenience for both infants and parents. Their snug design and gentle rocking motion help soothe babies and promote better sleep, mimicking the feeling of being held. Cradles are typically compact and lightweight, making them ideal for small spaces and easy to move between rooms. They often feature attractive designs that enhance nursery aesthetics and may include user-friendly elements like adjustable height. Additionally, having the cradle nearby encourages parent-infant bonding through more frequent interaction during feeding, soothing, and playtime.

Baby cradles have a wide range of applications, primarily serving as a safe and comfortable sleeping space for infants at home. They are also popular for travel due to their portable and foldable designs. In caregiving settings like daycare centers and hospitals, cradles provide short-term infant care. Additionally, they hold cultural significance in many traditions and are often used in rituals or as symbols of new life. Cradles are also commonly given as thoughtful gifts during baby showers. While offering comfort and improved sleep, parents should consider safety and age limitations when choosing the right cradle.

CONCLUSION AND FUTURE SCOPE

The IoT-based baby monitoring system for a smart cradle offers an innovative and practical solution to modern parenting challenges by integrating advanced technology with traditional infant care. Through the use of sensors and mobile connectivity, the system provides real-time monitoring of environmental conditions, baby movements, sound detection, and hygiene alerts, enhancing the safety, comfort, and well-being of infants. Features such as automated cradle swinging and live video streaming allow parents to monitor and soothe their babies remotely, reducing stress and improving convenience. This project not only demonstrates the potential of IoT in enhancing child care but also paves the way for further development of smart, data-driven parenting tools that adapt to evolving needs.

The IoT-based baby monitoring system for a smart cradle holds significant potential for future development and innovation. Upcoming enhancements could include the integration of artificial intelligence (AI) to analyze baby behavior patterns and predict needs such as feeding or sleep schedules. Machine learning algorithms can also improve cry detection accuracy and provide personalized responses. Further, incorporating wearable health monitoring devices can enable continuous tracking of vital signs like heart rate, oxygen levels, and body temperature, offering deeper health insights.

Expansion into cloud-based data storage and analysis could allow long-term health tracking and sharing of reports with healthcare professionals for remote consultation. The system could also benefit from enhanced security features like blockchain for data privacy and integrity, especially in hospital or daycare settings. Voice recognition and touchless control options might offer more convenience, and multilingual support in the mobile app could make the system more accessible globally. As smart home ecosystems evolve, seamless integration with other IoT devices (like smart lights or thermostats) could make the cradle a central part of a fully automated nursery environment.

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